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Research Report 1298

ON SUSTAINING PROCEDURAL SKILLS OVER PROLONGED RETENTION INTERVALS

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TRAINING TECHNICAL AREA

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The purpose of this research was to determine: (1) if the long-term retention of procedural skills depends on how periodic, "refresher" training sessions are scheduled, and (2) if soldiers can estimate in advance of retention testing how much training they require to regain proficiency. Thirty-eight Army reservists were divided into three groups and trained under one of the following schedules: Control, where initial training continued until the soldier achieved a criterion of one

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errorless performance; Massed Sessions (MS), where initial training was extended 100% beyond criterion performance; and Spaced Sessions (SS), where 100% overtraining trials were provided midway through the retention interval. Performance was measured on the disassembly and assembly of the M60 machinegun, and it was measured following 8 weeks of no practice. Immediately prior to retention testing and retraining, soldiers completed a questionnaire designed to assess whether they could estimate the amount of training they required to regain proficiency on the experimental task.

Key findings were: (a) soldiers did not forget substantially more following 8 weeks of no practice than following 4 weeks of no practice; (b) SS and MS soldiers performed with equal facility during retention testing and relearning, outperforming their counterparts in the Control group; and (c) as a group, soldiers demonstrated knowledge of how much training was required for them to regain proficiency on the experimental task.

When amount of training is held constant, a massed sessions approach to training can be as effective as a spaced sessions approach. The costs and risks associated with refresher training procedural skills can be reduced through the use of a massed sessions approach, at least for procedural tasks which are not particularly dangerous or fatiguing.

Data on the feasibility of using soldier-generated retention estimates to facilitate predictions about the scheduling of refresher training were suggestive but not definitive, and require more development.

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ON SUSTAINING PROCEDURAL SKILLS OVER PROLONGED RETENTION INTERVALS

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Education and Training

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FOREWORD

The Training Technical Area of the Army Research Institute for the Behavioral and Social Sciences (ARI) maintains a program of research in support of the systems engineering approach to training. A major focus of this research is the development of fundamental data and technology necessary to field integrated systems for improving individual job performance.

This report is one of a series of specific topics in the area of skill acquisition, retention and transfer. The long-term goal is to develop methods for predicting skill loss for all types of tasks and for determining effective training procedures for minimizing this loss. The work was accomplished by ARI personnel under Army Project 2Q263743A794, FY80, "Education and Training," in response to a request from Commander, US Army Training Support Center, Fort Eustis, Virginia. The support of Headquarters, 310 TAACOM, Fort Belvoir, Virginia during the conduct of this research is gratefully acknowledged.

Joseph Zeidner

JOSEPH ZEIDNER
Technical Director

ON SUSTAINING PROCEDURAL SKILLS OVER PROLONGED RETENTION INTERVALS

BRIEF

Requirement:

To determine: (1) if the long-term retention of procedural skills depends on how periodic, "refresher" training sessions are scheduled, and (2) if persons can estimate in advance of retention testing how much training they require to regain proficiency.

Procedure:

Thirty-eight Army reservists were divided into three groups and trained on the disassembly and assembly of the M60 machinegun, under one of the following schedules: Control, where initial training continued until each soldier achieved a criterion of one errorless performance; Massed Sessions (MS), where initial training was extended 100% beyond criterion performance; and Spaced Sessions (SS), where 100% overtraining trials were provided midway through the retention interval. Retention of task performance was measured after 8 weeks of no practice for all groups and also after 4 weeks for the SS group. Immediately prior to retention testing, soldiers completed a questionnaire which assessed their ability to estimate the amount of training they required to regain proficiency on the experimental task.

Findings:

(1) During initial training, groups achieved criterion at the same rate and, on achieving criterion, demonstrated equal proficiency on the experimental task.

(2) MS and SS groups showed evidence of continued learning during overtraining.

(3) Control soldiers did not forget substantially more following 8 weeks of no practice than did SS soldiers following 4 weeks of no practice.

(4) SS soldiers showed 57% fewer errors at the retention test than Control soldiers; MS soldiers showed 65% fewer errors than the Controls.

(5) SS and MS soldiers performed equally well at the 8 week retention test.

(6) MS soldiers performed significantly better after 8 weeks of no practice than SS soldiers performed after 4 weeks of no practice.

(7) Groups' performance during retraining virtually mirrored their performance at the retention test. Groups differed significantly in their rates of learning, with groups receiving additional training, generally, outperforming the Control group.

(8) As a group, soldiers were able to predict how much training they needed to regain task proficiency. Individually, however, they were not good predictors of their training requirements.

Utilization of Findings:

Refresher training is costly, entailing time, personnel, and equipment costs which are necessary when training is periodic. Scheduling of refresher training also is risky in that emergencies can arise before an individual has had an opportunity to retrain. This research suggests that, for procedural tasks which are not particularly dangerous or fatiguing, it may be possible to sustain proficiency better by scheduling half as many refresher training sessions and doubling the amount of training provided at each session. This manipulation should reduce administrative costs because refresher training occurs 50% less often, and should reduce risk because it reduces task forgetting rate.

This research also suggests that soldiers may be capable of predicting how much training they require to regain proficiency on procedural tasks. If so, soldier-generated retention estimates may aid predictions about when and how much training is required to sustain skills continuously at high levels. Additional research is needed, however, to confirm this notion.

ON SUSTAINING PROCEDURAL SKILLS OVER PROLONGED RETENTION INTERVALS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ON SUSTAINING PROCEDURAL SKILLS OVER PROLONGED RETENTION INTERVALS

INTRODUCTION

Procedural skills, typically, involve series of discrete motor responses (responses with a distinct beginning and end). These responses usually are self-paced and easy to execute. The main problem for the learner is response selection, i.e., deciding what responses to make and in what sequence to make them. Familiar examples of procedural tasks include most repair jobs (e.g., carburetor repair) and disassembly/assembly tasks (e.g., weapons disassembly/ assembly) as well as serial-manipulation tasks involving flipping switches, moving levers, or setting dials in sequence (e.g., Grimsley, 1969; Mengelkoch, Adams & Gainer, 1971).

Procedural skills are contrasted with skills involving continuous responses (responses without a recognizable beginning or end). Continuous responses, typically, are externally paced and require practice to acquire. Examples of continuous tasks include tracking (e.g., Fleishman & Parker, 1962), as is used in vehicular control, and balancing (e.g., Roehrig, 1964).

Retention data indicate that procedural skills are more likely to be forgotten over a retention interval than continuous skills. For example, Adams and Hufford (1962), investigating the effects of whole- and part-task training on the retention of a complex bomb-toss maneuver, found a 95% loss of procedural response proficiency over a 10-month retention interval, but found no effect on the retention of continuous flight control responses. Similarly, Mengelkoch et al., (1971) concluded that, although the forgetting of cockpit procedures over a 4-month retention interval could impair a pilot's flying efficiency and safety, this interval was not sufficient to degrade a pilot's continuous aircraft-control skills. This susceptibility of procedural skills to forgetting plus the knowledge that procedural skills dominate many Army jobs, led to the selection of a procedural task as the focus for this research.

OBJECTIVES

The research addressed the problem of how periodic, "refresher" training sessions should be scheduled to sustain procedural skills. The specific objectives were to determine (1) if scheduling is an important variable for the long-term retention of these skills, and (2) if persons can estimate in advance of retention testing how much training they require to regain proficiency.

Scheduling of Training

Research related to the effects of scheduling of training on retention suggests that scheduling is not an important variable for the retention of procedural skills as long as amount of training is held constant (e.g., Catalano, 1978; Schmidt, 1975). This past research, however, differs from the research reported here. Past research was concerned with the scheduling of

training trials and focused on the length of rest pauses between successive trials. The present research was concerned with the scheduling of training sessions and focused on the length of the retention interval between successive sessions. Rest pauses between successive training trials were left unchanged.

The practical significance of varying scheduling can be demonstrated using a concrete example. Currently, the Army relies on periodic refresher training to sustain skills. If time intervals between training sessions are too long, then performance may fall below acceptable levels and entail considerable risk. Emergencies can arise, requiring correct performance, before an individual has had an opportunity to retrain. If time intervals between training sessions are too short, then administrative costs are unnecessarily inflated.

One way to reduce the costs and risks associated with refresher training may be to mass refresher training sessions while holding amount of training constant. For example, assume that individuals receive refresher training on some particular task once every month. Assume further that, for any particular individual, training continues only until proficiency has been achieved. If amount of training is a more important variable for retention than the manner in which training is scheduled (e.g., Bilodeau & Bilodeau, 1961; Schmidt, 1975), it may be possible to sustain proficiency by scheduling half as many refresher training sessions and doubling the amount of training provided at each session. This manipulation should reduce costs because refresher training occurs 50% less often. Similarly, it should reduce risk because individuals' needs for refresher training arise at half the old rate. Of course, it remains to be seen whether a soldier trained under a massed schedule can learn and retain as much information as one trained under a spaced schedule. This research was designed to test this possibility.

Predicting Retention

Information is lacking on how long and how often individuals need to practice particular skills to maintain proficiency. Generally speaking, retraining times are longer for longer retention intervals (e.g., Ammons, Farr, Bloch, Neumann, Dey, Marion, & Ammons, 1958), more difficult tasks (e.g., Lersten, 1969), procedural tasks than for continuous tasks (e.g., Ammons et al., 1958), and for highly skilled performers than for novices (e.g., Ammons et al., 1958). Currently, however, predictions concerning the optimal duration and frequency of refresher training for any particular skill depend primarily on conjecture. The result is that one is forced to decide between (1) committing resources to sustaining proficiency continuously at high levels or (2) approaching the task of scheduling refresher training in an unsystematic way.

What can be done to remedy this problem? Evidence suggests that individuals can read their own memory states with fair accuracy (e.g., Flavell & Wellman, 1977; Hart, 1965; Hunt, 1980; Yussen & Levy, 1975). If this is the case, it may be possible to have trainees predict how

much refresher training they need to sustain particular skills and adjust refresher training schedules accordingly. The advantage of such an approach toward predicting retention lies in its simplicity. Retention estimates could be generated for any task and collected using a questionnaire. Of course, safeguards would have to be instituted to ensure that trainees provide honest estimates, but these safeguards need not be complicated. For example, trainees might be required to produce retention estimates only for tasks on which they are about to be tested or think they are about to be tested. Alternatively, individuals might be asked to generate retention estimates for skills they have acquired but which they are no longer expected to maintain. In any event, the collection of retention estimates is a technical concern that can be overcome. The question which needs to be asked is whether it is worthwhile to collect these estimates in the first place. This research was designed to answer this question.

METHOD

Experimental Design

The experimental task involved a simplified version[1] of the general disassembly/assembly of the caliber 7.62 millimeter, M60 machinegun (Department of the Army, FM 23-67, 1964) as shown in Appendix A. This task was selected because it could be scored on 35 distinct procedures and because soldiers must know how to perform it in the absence of memory prompts (e.g., skill performance aids). A trial was counted each time a soldier completed both the disassembly and assembly of the weapon. The number of trials each soldier performed depended, in part, on the amount of training each soldier required to achieve a criterion of one errorless trial and, in part, on the group's training schedule. The training schedule for each group is depicted in Figure 1. During initial training, soldiers in the Control group were trained to criterion on the task. They were then tested for retention and retrained to criterion following an 8-week retention interval. Soldiers in the Massed Sessions (MS) group were trained to criterion and then received 100% overtraining on the task. Thus, for example, if a soldier in the MS group required two trials to achieve one errorless disassembly and assembly of the weapon, he/she received two additional trials as part of initial training. MS soldiers also were tested for retention and retrained to criterion following an 8-week retention interval. Soldiers in the Spaced Sessions (SS) group received the same amount of training as those in the MS group, but their training was scheduled differently. SS soldiers were trained to criterion and then received their 100% overtraining trials halfway through the 8-week retention interval. Thus, if a soldier in the SS group required two trials to achieve criterion on the task initially, he/she received two additional refresher training trials 4 weeks before being tested for retention and retrained.

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[1]Time constraints necessitated that the task be simplified. Therefore, stock and buffer groups were not treated independently. Soldiers removed (replaced) both groups simultaneously by removing (replacing) the buffer yoke. This particular simplification was employed because stock and buffer groups, reportedly, rarely require separation or repair.

GROUPS	SESSIONS				
Control	Initial Training	- - - - - 8 weeks - - - - -			Retention Testing and Retraining
Massed Sessions (MS)	Initial Training Plus 100% Overtraining	- - - - - 8 weeks - - - - -			Retention Testing and Retraining
Spaced Sessions (SS)	Initial Training	- - - 4 weeks - - -	Refresher Training (100% Over-training)	- - - 4 weeks - - -	Retention Testing and Retraining

Figure 1. Experimental design

Materials and Procedure

Initial training (all groups). On entering the test room each soldier received a questionnaire (Appendix B). This questionnaire was designed, primarily, to obtain information about the soldier's previous training on the experimental task, but it also served as a means for gathering demographic data on our sample (e.g., sex, age). Each soldier then received instructions relevant to their group (Appendix C). As part of these instructions soldiers were informed that their performance would be scored in terms of both speed and accuracy. The need for accuracy was emphasized over the need for speed. Following the instructions and a demonstration on how the disassembly and assembly of the weapon should be accomplished, hands-on training began. The experimenter started a standard stopwatch when the soldier began disassembling (assembling) each major parts group (i.e., stock/buffer groups, operating group, trigger housing group, barrel group) and stopped the stopwatch when the soldier had completed it. The experimenter also signaled the soldier to stop performing at that time. When the experimenter had recorded the disassembly (assembly) time to the nearest second, he told the soldier to begin disassembling (assembling) the next parts group. If, at any point during a trial, a soldier made an error, the experimenter showed the soldier the correct procedure and required the soldier to perform it before continuing. An error was counted each time a procedure was omitted or performed out of order. Soldiers typically achieved criterion performance in about 30 minutes. An additional 15 to 20 minutes usually were required to train 100% beyond criterion.

Refresher training (SS group only, week 4). On entering the test room, SS soldiers filled out a second questionnaire (Appendix D). This questionnaire served as a means for collecting retention estimates. Each soldier then was told the number of trials he/she was expected to complete and reminded about how performance was scored. No demonstration was provided prior to hands-on training. Otherwise, the procedure during refresher training was identical to that used during initial training.

Retention testing and retraining (week 8). Prior to the onset of retention testing (i.e., Trial 1 retraining). Soldiers responded to the questionnaire that asked for retention estimates (Appendix D). They were then reminded about how performance was scored. They did not receive a demonstration prior to retention testing. Retraining continued only until criterion performance had been achieved. Otherwise, the procedure used during this period was the same as that used during initial training.

Subjects

Forty-two Army reservists from Headquarters, 310 TAACOM, Fort Belvoir, Virginia, were assigned randomly to groups with the constraint that sex and previous training on the experimental task be roughly equated across groups. Thirty-eight soldiers completed all phases of the experiment.

The control group included nine males and five females, the MS group included seven males and five females, and the SS group included seven males and five females. Of those soldiers reporting previous experience on the experimental task, nine were in the Control group, five were in the MS group, and seven were in the SS group. The median soldier's age was 28 years, and the range was 41 (18-59) years. All soldiers were treated individually. None reported receiving any outside training on the experimental task while the experiment was in progress.

RESULTS AND DISCUSSION

Two soldiers in the MS group inadvertently received only one overtraining trial rather than being trained 100% beyond criterion. To equate MS and SS groups in terms of amount of training, these soldiers' data were not included in the analyses that follow. However, these soldiers' data were included in the analyses of the retention estimates. Presumably, the amount of training received does not affect one's ability to produce a retention estimate, only the size of that estimate.

Training, retention, and relearning data for groups were analyzed using separate one-way analyses of variance (ANOVAs) rather than submitting them to an overall Group X Session mixed factoral ANOVA. The mixed factorial ANOVA was deemed inappropriate for two reasons:

(1) MS and SS groups were trained 100% beyond criterion; the Control group was not. Thus, amount of training could not be represented by a single between-subjects factor.

(2) Soldiers were shown explicitly how to perform the experimental task prior to initial training, but not prior to retention testing or retraining. Thus, the type of training soldiers received during these two periods could not be represented by a single within-subject factor.

Acquisition

Questionnaire data suggested that groups had similar amounts of pre-experimental experience on the experimental task. This conclusion was supported statistically in analyses of the rates and levels of learning achieved by the three groups. These analyses indicated that groups' errors to criterion, $\underline{F}(2,33) = 2.12$, trials to criterion, $\underline{F}(2,33) = 1.91$, and criterion trial times, $\underline{F}(2,33)$ 1 did not differ significantly[2]. Groups achieved criterion at the same rate and, on achieving criterion, demonstrated equal proficiency on the experimental task.

What effect did the scheduling variation have on final learning levels?

Most soldiers in the MS group continued to perform errorlessly during overtraining. Only two erred, and each of them erred only once. This group's mean trial times also improved significantly, $\underline{F}(1,9) = 12.74$, dropping from 189.6 seconds at criterion to 152.2 seconds on the

[2] The rejection region equalled .05 in all cases.

last trial of overtraining. This improvement suggests that the MS soldiers were continuing to learn during overtraining.

In contrast, SS soldiers erred relatively frequently during refresher training. They averaged 5.25 errors on Trial 1 and only five were performing errorlessly by the end of the session. Trial 1 errors can be attributed to the effects of forgetting whereas failure to regain proficiency during refresher training probably stems from the fact that no demonstration was provided.

Of the five soldiers achieving criterion during refresher training, four showed shorter trial times over the session. This trend toward shorter trial times, viewed in conjunction with retention and relearning data reported later, suggests that refresher training induced new learning. The idea that refresher training can induce new learning also is supported by research reported elsewhere (e.g., Hagman & Schendel, 1979).

Retention

Errors on the first trial of refresher training (SS group only) and retraining were used to index retention. These errors, averaged across soldiers within groups, are presented in Table 1. Table 2 presents the mean error differences between groups at retention along with the results of Newman-Keuls pairwise comparisons. Three results indicated by these tables warrant special attention.

a. Soldiers did not forget substantially more over the 8-week retention interval than over the 4-week retention interval. The relevant data are shown in Table 1, the comparison of interest being between the Control group's mean errors at Trial 1 of retraining and the SS groups, mean errors on Trial 1 of refresher training, $\underline{F}(1,24) < 1$.

b. Groups did not retain equal amounts of procedural skill, $\underline{F}(2,33) = 4.41$. SS soldiers showed a 57% advantage over their counterparts in the Control group, while MS soldiers showed a similar 65% advantage. The relevant data appear in Table 1. The differences between the Control group's mean errors and the other two groups' mean errors at Trial 1 of retraining were both significant as shown in Table 2. These retention differences were caused by differences in levels of original learning present among groups. They support previous research suggesting that degree of original learning is an important determinant of task retention (e.g., Schendel, Shields & Katz, 1978). Differences in the degree of original learning between the MS and SS groups also resulted in the MS group having better retention at 8 weeks after initial training than the SS group had at 4 weeks after initial training, $\underline{t}(20) = 1.88$, $\underline{p} < .05$.

c. The manner in which training sessions were spaced temporally did

Table 1

Mean Errors for Soldiers in Each Group at Trial 1 of Refresher Training (SS group only) and Retraining

	SESSION	
Group	Refresher Training	Retraining
Control	--	6.21
Massed Sessions (MS)	--	2.20
Spaced Sessions (SS)	5.25	2.67

Table 2

Mean Error Differences Between Groups at Trial 1 of Retraining

	Massed Sessions (MS)	Spaced Sessions (SS)	Control
Massed Sessions (MS)	--	.47	4.01*
Spaced Sessions (SS)		--	3.54*
Control			--

Note. *$p < .05$.

not affect retention[3]. The comparison of key concern here is between the MS and SS groups' mean errors at Trail 1 of retraining (Table 1). As shown in Table 2, the difference between these means was not significant. This result supports the view that procedural skills can be sustained equally well using massed or spaced training sessions. It also extends earlier research showing that massing training does not affect the acquisition or performance of procedural tasks (e.g., Catalano, 1978; Schmidt, 1975).

Retraining

Table 3 presents each groups' mean errors to criterion and mean trials to criterion during retraining. Groups' performance during retraining was similar to their performance on Trial 1. Groups differed significantly in terms of both errors to criterion, $F(2,33) = 4.43$ and trials to criterion, $F(2,33) = 3.69$, with groups receiving additional training, (MS and SS), generally, outperforming the Control group.

Table 3

Mean Errors to Criterion and Mean Trials to Criterion for Each Group during Retraining

Group	Errors to Criterion	Trials to Criterion
Control	7.43	2.43
Massed Sessions (MS)	3.20	1.90
Spaced Sessions (SS)	2.67	1.58

---

[3]The present design confounds training schedule (MS versus SS) with post-training retention interval (8 weeks versus 4 weeks). As a result, it is unclear whether the SS group equalled the MS group at retention because of its training schedule or because it had a shorter post-training retention interval. With equal post-training retention intervals, the MS group may have outperformed the SS group. On the other hand, the observation that forgetting was restricted to the first 4 weeks of no practice suggests that the two groups would have performed equally had they each experienced an 8-week post-training retention interval.

Table 4 presents the differences between groups' mean errors to criterion (top half) and mean trials to criterion (bottom half) along with the results of Newman-Keuls pairwise comparisons. One result in this table is at variance with results reported earlier for retention. The MS and Control groups did not differ in terms of trials to criterion during retraining. While discrepant, this finding should not alter the interpretation of the data. MS soldiers required 22% fewer trials to relearn the task than Control soldiers. That this result failed significance can most reasonably be attributed to the relative insensitivity of trials to criterion (vis-a-vis errors to criterion) to changes in soldier's performance.

Table 4

Differences between Groups' Mean Errors to Criterion (top half) and Mean Trials to Criterion (bottom half)

	Spaced Sessions (MS)	Massed Sessions (SS)	Control
Spaced Sessions (SS)	--	.53	4.76*
Massed Sessions (MS)		--	4.23*
Control			--
Spaced Sessions (SS)	--	.32	.85*
Massed Sessions (MS)		--	.53
Control			--

Note. *$p < .05$.

Following retraining, groups did not differ in terms of the total number of trials they had received during the experiment, $F(2, 33) = 1.05$. Groups also demonstrated equal proficiency on the experimental task, as indicated by their equivalent final criterion trial times, $F(2, 33) < 1$.

These results suggest that the amount of training provided soldiers was far more critical for learning and performance than the manner in which this training was scheduled.

Massing training sessions may degrade learning and performance on some tasks, particularly ones that are dangerous or fatiguing (e.g., Schmidt, 1975). Massing of training sessions also may degrade learning and performance if amount of training is not held constant (e.g., Schmidt, 1975). However, data obtained here and elsewhere (e.g., Catalano, 1978; Schmidt, 1975) suggest that, when amount of training is held constant, massed sessions can be as effective as spaced sessions in promoting the acquisition, retention, and retraining of procedural tasks.

Predicting Retention

Correlational analyses. Spearman rank-order correlations were computed between soldiers' descriptions of their knowledge of the experimental task (Question 1, Appendix D) and their actual performance during refresher training (SS group only) and retraining. These correlations are shown in Table 5 as a function of dependent variable. These correlations generally were low and positive. None reached significance.

A correlation was also computed between soldiers estimated and actual trials to criterion during retraining (Question 2, Appendix D). It also was nonsignificant ($n = 37$), $r = .08$. The failure to find a relationship between individual soldiers' estimated and actual performance is inconsistent with past evidence showing that persons know, in advance of responding, if and how well they retain particular tasks (e.g., Flavell & Wellman, 1977). It suggests that subjective retention estimates obtained from individual soldiers may not facilitate predictions about the scheduling of refresher training.

Error analyses. On the other hand, because it is possible to have a low correlation even when soldiers' estimates are in substantial agreement with actual scores, we examined soldiers' absolute and algebraic errors in estimating retention. Absolute error is a measure of response deviation magnitude without regard for the sign or direction of the deviation. Algebraic error is a measure of response deviation magnitude with regard for the sign or direction of the deviation. Although our main concern was for the absolute magnitude of the deviation between soldiers' estimated (Question 2, Appendix D) and actual trials to criterion during retraining, we also were interested in the direction of this error to determine whether soldiers tended to overestimate or underestimate the amount of retraining they needed to regain proficiency.

Table 6 shows the groups' mean absolute and algebraic errors in estimating trials to criterion during retraining. These errors are quite small and indicate that as a group soldiers accurately estimated the number of retraining trials required to restore criterion performance. The size of these errors may be deceiving, however, in that on the average, soldiers required only 1.97 trials to retrain to criterion on the experimental task (See Table 3). Because so few actual trials were required, gross

underestimates were impossible. And thus, soldiers may have appeared to be better predictors than they actually were. On the other hand, soldiers must have had some knowledge about the amount of training required to regain proficiency on the task. While gross underestimates were impossible, there was nothing to prevent soldiers from overestimating trials to retrain. An examination of the distribution of soldiers' errors in estimating retraining requirements indicated that large overestimates occurred infrequently, that the modal value for soldiers' errors was zero, and that 73% of the soldiers' estimates were within one trial of being correct.

Table 5

Correlations Between Soldiers' Descriptions of Their Knowledge of the Experimental Task (Question 1, Appendix D) and Their Actual Performance during Refresher Training (SS group only) and Retraining

	Trial 1 Errors	Errors to Criterion	Trials to Criterion
Refresher Training (n = 13)	.37	--	--
Retraining (n = 35)	.16	.19	-.07

Note. The number of soldiers who responded to Question 1, Appendix D, appears in parentheses.

Table 6

Groups' Mean Absolute and Algebraic Errors in Estimating Trials to Criterion during Retraining

Group	Mean Absolute Errors	Mean Algebraic Errors
Control (n = 14)	.86	-.14
Massed Sessions (MS) (n = 12)	1.58	.08
Spaced Sessions (SS) (n = 11)	.91	.00
Total (n = 37)	1.11	-.03

Note. The number of soldiers in each group who responded to Question 2, Appendix D, appears in parentheses.

CONCLUSIONS

This research addressed the problem of sustaining procedural skills continuously at high levels. At least one result reported here bears directly on this problem. When amount of training was held constant, massed training sessions were as effective as spaced sessions in promoting the acquisition, retention, and retraining of the experimental procedural task. This result suggests that the costs and risks associated with refresher training procedural skills can be reduced, at least for those tasks which are not particularly dangerous or fatiguing.

Data on the feasibility of using soldier-generated retention estimates to facilitate predictions about the scheduling of refresher training were suggestive, but not definitive. Individual soldiers were unable to predict how much training they needed to regain task proficiency. However, as a group, their predictions were quite accurate. Soldiers predictions regarding the amount of refresher training required to regain task proficiency may have been influenced by the small number of trials actually needed to retrain. To address the issue of soldier-generated retention estimates more fully, additional research is needed using tasks tht demand more retraining trials.

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APPENDIX A

PROCEDURES INVOLVED IN THE GENERAL DISASSEMBLY/ ASSEMBLY OF THE M60 MACHINEGUN

PARTS GROUPS: DISASSEMBLY

1. INITIAL CONDITIONS

   a. Bolt forward.

   b. Cover closed.

   c. Safety on safe.

2. STOCK/BUFFER GROUPS

TOTAL TIME ________

	GO	NO GO
a. Raises cover.	__	__
b. Removes buffer yoke from receiver top.	__	__
c. Removes stock and buffer assembly by pulling to rear.	__	__

3. OPERATING GROUP TOTAL TIME ________

	GO	NO GO
a. Places safety on fire position.	__	__
b. Pulls drive spring guide and drive spring from receiver and separates them.	__	__
c. Pulls cocking handle to rear until bolt separated from barrel socket.	__	__
d. Exposes operating rod and bolt.	__	__
e. Grasps securely to prevent rotation.	__	__
f. Removes from receiver.	__	__
g. Allows slow bolt rotation.	__	__
h. DOES NOT SEPARATE BOLT FROM OPERATING ROD.	__	__

4. TRIGGER HOUSING GROUP TOTAL TIME ________

	GO	NO GO
a. Rotates rear end of leaf spring up and removes it.	__	__
b. Removes trigger housing pin by pushing it to the left.	__	__
c. Removes trigger housing.	__	__

5. BARREL GROUP TOTAL TIME ________

	GO	NO GO
a. Pushes in on the barrel locking lever plunger and raises lever to vertical position.	__	__
b. Removes barrel assembly by pulling it straight to the front.	__	__

PARTS GROUPS: ASSEMBLY

1. BARREL GROUP — TOTAL TIME ________

	GO	NO GO
a. Inserts rear of barrel under barrel cover.	___	___
b. Lowers barrel locking lever.	___	___

2. TRIGGER HOUSING GROUP — TOTAL TIME ________

	GO	NO GO
a. Inserts trigger housing in recess in bottom of receiver.	___	___
b. Inserts trigger housing pin from left.	___	___
c. Engages front of leaf spring with trigger housing pin, insuring that leaf spring is placed so that bent part is against side of trigger housing.	___	___
d. Rotates rear end of leaf spring down so that it engages sear pin.	___	___

3. OPERATING GROUP — TOTAL TIME ________

	GO	NO GO
a. Holds operating rod with one hand.	___	___
b. With second hand, pushes forward on rear of bolt until locking lugs are vertical.	___	___
c. With cam roller, up pushes operating rod and bolt into bottom of receiver.	___	___
d. Inserts drive spring guide into drive spring.	___	___
e. Inserts opposite end of drive spring into recess of operating rod.	___	___
f. Pulls trigger.	___	___
g. Pushes in drive spring until head of guide is one inch from receiver.	___	___

4. STOCK/BUFFER GROUPS TOTAL TIME ________

	GO	NO GO
a. Inserts buffer plunger into drive spring guide.	___	___
b. Aligns guide rails of stock with guide rails on receiver and pushes forward until click is heard.	___	___
c. Replaces buffer yoke.	___	___

5. FUNCTION CHECK TOTAL TIME ________

	GO	NO GO
a. Pulls bolt to rear with cocking handle.	___	___
b. Closes cover.	___	___
c. Pulls trigger.	___	___

APPENDIX B

QUESTIONNAIRE ON PREVIOUS TRAINING

NAME ______________________________ SSN ______________________________

AGE ______________________________ SEX M F

MOS ______________________________ GRADE ______________________________

BN ____________________ CO ____________________ PLT ____________________

Instructions

Please answer the following question.

Have you received any training on the general disassembly/assembly of the M60 machinegun?

YES NO

If yes, please complete this questionnaire. If no, do not continue. Wait for further instructions.

1. Where did you receive training on this task? (Circle one or more answer.)

   a. Basic Training

   b. Advanced Individual Training

   c. Unit Training

   d. Other (Specify) ______________________________

2. What kind of training was it?

   a. Lecture/Demonstration

   b. Hands-on

   c. Both

   d. Other (Specify) ______________________________

3. How frequently have you performed this task?

a. Weekly

b. Monthly

c. Yearly

d. Less than once a year

4. Approximately how long has it been since you last performed this task? (Fill in the blank.) ______________________________

APPENDIX C

INITIAL INSTRUCTIONS
CONTROL AND SPACED SESSIONS GROUPS

This research is being conducted by the Army Research Institute in responce to a request from Department of the Army. The purpose of the research is to explore different means of training individuals so that forgetting is minimized. Please do your best as our results will be used to help shape Army training in the future.

Your job will be to learn the procedures involved in the disassembly and assembly of the M60 machinegun. Your performance will be evaluated in two ways. First, we will be scoring your errors. An error will be counted each time you fail to perform a particular procedure or perform it incorrectly. Each time you make an error, we will stop you and demonstrate the correct procedure. Following this demonstration, we want you to try to perform the correct procedure again. You will then be allowed to continue. Is that clear?

We also will be recording the time you take in disassembling and assembling each of the major components, or part groups, of the M60--for example, the trigger housing group, the barrel group, the operating group, and so on. We will identify the major groups for you later when we demonstrate the procedure to use in performing the task. Do you have any questions so far?

Remember, it is important that you work as quickly and as accurately as possible. Accuracy is especially important as your trining will continue until you do the task without an error. Is that clear?

Ok, let me show you how it's done.

APPENDIX C

INITIAL INSTRUCTIONS
MASSED SESSIONS GROUP

This research is being conducted by the Army Research Institute in response to a request from Department of the Army. The purpose of the research is to explore different means of training individuals so that forgetting is minimized. Please do your best as our results will be used to help shape Army training in the future.

Your job will be to learn the procedures involved in the disassembly and assembly of the M60 machinegun. Your performance will be evaluated in two ways. First, we will be scoring your errors. An error will be counted each time you fail to perform a particular procedure or perform it incorrectly. Each time you make an error, we will stop you and demonstrate the correct procedure. Following this demonstration, we want you to try to perform the correct procedure again. You will then be allowed to continue. Is that clear?

We also will be recording the time you take in disassembling and assembling each of the major components, or part groups, of the M60--for example, the trigger housing group, the barrel group, the operating group, and so on. We will identify the major groups for you later when we demonstrate the procedure to use in performing the task. Do you have any questions so far?

Remember, it is important that you work as quickly and as accurately as possible. Accuracy is especially important as your training will continue until you have performed <u>twice</u> the number of trials taken to do the task without an error. For example, if you took 3 trials to do the task correctly, you will be asked to do the task 3 more times. Is that clear?

Ok, let me show you how it's done.

APPENDIX D

QUESTIONNAIRE FOR COLLECTING SUBJECT-GENERATED RETENTION ESTIMATES

NAME ______________________________ SSN ____________________

AGE ______________________________ SEX M F

MOS ______________________________ GRADE ____________________

BN ________________ CO ________________ PLT ________________

Instructions

Answer each question, selecting the best response alternative and placing an "X" next to it.

1. Describe your knowledge of the procedures involved in the general disassembly/assembly of the M60 machinegun.

   a. Excellent

   b. Good

   c. Only Fair

   d. Poor

   e. Terrible

2. How many trials do you think it will take you to relearn this task?

a. 0	g. 6
b. 1	h. 7
c. 2	i. 8
d. 3	j. 9
e. 4	k. 10
f. 5	